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ABSTRACT

This instructor's guide describes the development of a sixteen-week postsecondary course in electrical mechanical maintenance. Following introductory sections that provide background information and a course summary, the third section describes the instructional model used in the course. Section 4 presents an overview of instructional media used in the course. The fifth section lists unit objectives and instructional materials for nine electrical units and six mechanical units. Electrical units include direct current theory, alternating current circuits, motors, power supplies, equipment and controls, 3-phase application, lighting and distribution, electrical safety, and preventative maintenance. Mechanical units include basic mechanics, bearing, lubrication, drive components, pumps, and mechanical safety. Section 6 is included to describe the field laboratory component and suggest projects. A final section gives the task analysis rankings by employers in the electromechanical industry and the survey tasks in maintenance curriculum skill areas. (LRA)

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ED190809

ELECTRICAL MECHANICAL MAINTENANCE

Instructors Guide

CE 026 294

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ELECTRICAL MECHANICAL MAINTENANCE

Pilot Course — 16 Weeks

Commenced: April 3, 1979 — Leon Leash, Instructor

8 College Credits

San Jose City College

Type of Course: Individualized self-paced instruction, group lecture, demonstration and hands-on laboratory, field project laboratory.

Education Level: Adult Industrial Training

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PREFACE

The instructors guide was developed in conjunction with a pilot course in Electrical/Mechanical Maintenance offered at San Jose City College Spring Semester 1979. The course is an important product of a federal grant project to provide a curriculum plan for maintenance technician articulated between industry, the community college and the Regional Vocational Center.

The basic model of the instructional program outlined in this manual is a combination of lecture, individualized, self-paced instruction and laboratory conducted at the college facility and on-the-job site. Refinement will be made in the development and integration of the modes of instruction as well as content throughout the delivery.

Evaluation and adjustments to the course design will be reflected in the final report for the EXCITE project due July, 1979.

Special acknowledgement of the considerable contributions "above and beyond the call of duty" go to the instructor, Mr. Leon Leash, Supervisor for Ford Aero Space, Engineering Services Division, Palo Alto, California. Mr. Leash has 20 years of electronic maintenance experience including electrical-mechanical in industry and education.

The students in the pilot course, employees from two participating companies: Xidex Corporation and National Semiconductor Corporation, are to be commended on their valour and candid commentary.
The following advisory committee was formed by San Jose City College to provide assistance in evaluation and planning the maintenance curriculum. The Electrical Mechanical course was a first charge consideration of the committee. We would like to thank them for their time and donations of instructional materials including equipment.

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1978-79

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I. INTRODUCTION

ELECTRO-MECHANICAL MAINTENANCE
INTRODUCTION

A common problem in industry today is a severe shortage of skilled maintenance people. Maintenance technicians are among the most highly skilled and highly paid hourly workers in industry. Their jobs require solid grounding in technical disciplines ranging from basic blueprint reading and shop math to advanced pneumatics, hydraulics and electrical/mechanical troubleshooting. A recent U. S. Government survey shows that 80 percent of American industrial firms are in immediate need of qualified maintenance technicians. To help solve this shortage, thousands of untrained workers enter the maintenance field each year receiving informal on-the-job training with uneven results. Training programs are required at three distinct levels:

- New technicians must be trained to match the growth of industry.
- Technicians with some experience must be trained to replace those lost through retirement and other forms of attrition.
- Experienced tradesmen periodically need refresher training to keep pace with new technology and the increasing complexity of equipment they are expected to maintain.

In addition cross training in a second or third area of specialization provides industry with a more flexible work force and the technician a more valuable position for advancement.

In order to offer courses that reflect the needs of the target audiences described above a broad spectrum of training experiences for technicians with widely varying skill levels and interests was needed. Therefore, it seemed that by combining supervised self study, traditional instructional techniques and a field laboratory component would offer the best solution and be the most effective in training for skill competency.

II. COURSE SUMMARY

II. COURSE SUMMARY

The Electro-Mechanical Maintenance course accepts students at all skill levels in the maintenance trades occupations. A pre-program survey of the abilities and the desires of the prospective students and their employers showed a need for a heavier emphasis on electrical theory maintenance rather than mechanical maintenance. The course content was designed around an approximate 60/40 electrical/mechanical ratio.

The instructional regimen was set up as follows:

Two three-hour classroom sessions per week. These included one three-hour lecture and one three-hour laboratory/demonstration. In addition, each student is assigned four hours per week on-the-job training projects at their place of employment. Each student is given individualized instructional material selected to provide conceptual knowledge of theory and principles of operation of systems and devices in the core units and selected skill training in specialized areas to satisfy individual course goals.

DC and AC theory are taught in the first three weeks relating these principles to the industrial environment. During this period the instructor familiarizes himself with the types of electro/mechanical systems the students will be required to perform maintenance upon at their various places of employment. This approach combines a practical understanding of electrical theory along with the traditional mathematical approach. The students are encouraged to come to succeeding classes with examples of equipment and descriptions of systems found at their place of employment that use the theory discussed in the previous classes.

A heavy emphasis is placed on safety and safe work practices both in the classroom and on-the-job visits by the instructor.

Use of electrical test instruments, particularly the types in common use for industrial maintenance, is integrated into these introductory weeks. The students are taught to calculate electrical circuit parameters and demonstrate proof of their calculations by verifying the measurements with the appropriate test instruments.

After the introductory weeks of basic electrical/electronic theory and use of test instruments the students' individualized self-paced programs commence. This approach takes into consideration the individual's course goal and assessment of the students skills, experience, the equipment the student is required to maintain and the student/employer expectations.

The remaining weeks of the course dedicated to the electrical section deal with specific devices and systems found in the industrial environment.

Having completed units on interpreting schematics and wiring diagrams combined with the theory and use of test equipment and diagnostic aids, the student begins troubleshooting electrical equipment. As the instructional units on various equipment and systems found in the industrial environment (such as motors, timers, lighting systems, control devices, etc) are completed the principles of operation, common documentation, fault isolation and repair of these systems are discussed or demonstrated in the classroom. Skill competency can be achieved if the students complete their field laboratory projects and apply newly acquired skills to these systems in industry. Students are encouraged to bring into class examples of the types of electrical equipment trouble shooting problems they encounter on the job so they may be discussed with the class and the principles and techniques learned in the classroom are reinforced.

At the end of the electrical section the individual student is expected to safely perform electrical maintenance on systems found at his place of employment using the documentation and test instruments available to him. The level of sophistication of the equipment one would be able to diagnose and maintain will of course vary depending on the previous experience of the individual student. However, each students' skill development should continue as they encounter situations on the job that relate to units of the course work.

Since much of the mechanical equipment found in industry (both plant facilities and industrial process equipment) use electrical control systems, an understanding of the operation of these mechanical devices is necessary so one may understand how the electrical controls sequence these devices or systems through their processes. As in the electrical section, lecture in basic core units is combined with individualized instructional programs in selected skill areas from students' level of experience and course goal and from the types of equipment he is expected to maintain on the job.

Instruction in the mechanical section emphasizes safety and safe working practices throughout the session.

Basic mechanical principles are taught in the first weeks. At this time the student will be introduced to calculations of applied mechanics, the use of test instruments and common documentation used with mechanical systems. From previous visits to-the-job sites, the instructor will be acquainted with mechanical systems that incorporate the principes to be discussed in the classroom. This information will be integrated into lectures, laboratory/demonstrations, and suggestions for field projects.

After learning the basics of mechanics, as they relate to the types of devices found at the students' place of employment, the student will learn to use mechanical schematics and diagrams and test instruments to locate, diagnose and correct mechanical problems.

Along with the theory and practice of electro/mechanical maintenance, the students are expected to familiarize themselves with the record keeping, scheduling, parts ordering, failure reports, etc. and other aspects of the maintenance paperwork system used at their company.

In addition the student should be able to obtain the schematics/blueprints for the equipment they are going to work on from their facilities library by understanding how the plans are kept and how they are taken out of the library.

Persons in maintenance occupations, as they work in various areas of their facilities each day, come into contact with a great number of company employees. As the maintenance person answers trouble calls to fix equipment, part of his trouble diagnosis will be asking the person who turned in the failure report what the symptoms are. How the maintenance man gets along with others may dictate the quality of the answers he receives and determine how quickly the diagnosis and repair can be done. Since the person reporting the failure may already be upset because the work they were doing has stopped, some of the tools of the maintenance technician will bring to the job are tact and diplomacy. Getting along with supervisors, peers and other employees while going about the maintenance tasks will be emphasized along with the theory and practice of maintenance throughout the course.

The overall general goal is to train industrial maintenance technicians to work effectively with a minimum of supervision, locating, diagnosing and correcting electro/mechanical system failures, maintaining all the appropriate records required by their companies maintenance paperwork system while interfacing with other personnel in the plant.

III. INSTRUCTIONAL MODEL

A. FLOW CHART
B. CORE UNITS
C. SPECIFIC SKILL AREA
D. COUNSELING

ELECTRO-MECHANICAL MAINTENANCE

Figure A

APRIL 3
5
10
12
17
19
24
26
MAY 1
3
8
10
15
17
22
24
29
31
JUNE 5
7
12
14
19
21
26
28

BASIC ELECTRICITY

UNITS:
1/ Current 2/ Voltage 3/ Resistance 4/ Measuring, Voltage, & Current 5/ Relation of Current, Voltage & Resistance 6/ Parallel Circuits 7/ Series Parallel Circuits 8/ Magnetism, Electromagnetism 9/ Inductance 10/ Capacitance

AC THEORY

MOTORS

AC, DC, SINGLE PHASE

POWER SUPPLIES

EQUIPMENT AND CONTROLS

DC AND AC
STARTERS, SWITCHES, TIMERS, COUNTERS, CONTROLLERS

3 PHASE APPLICATION

Distribution, Motor, Alternators, Generators, Starting Principles, Controllers

LIGHTING AND DISTRIBUTION

PREVENTATIVE MAINTENANCE PROCEDURES, SCHEDULES

Basic Mechanics

Bearings

Lubrication

Drive Components

Pumps

Preventative Maintenance Procedures

DC THEORY

PROTECTIVE DEVICES

SAFETY

Mechanical Troubleshooting

SAFETY

MEASURING INSTRUMENTS

SCHEMATICS

ELECTRICAL TROUBLESHOOTING

Blueprints/ Schematics

III. Instructional Model

B. Core Units

1. Entry Behavior. Each student will have some skills which are prerequesites to registering in the course. However, students will vary (refer to learner characteristics in Media Selecton) in their skills and degree of proficiency. Students can self administer tests at the end of each chapter in the core course to determine at which point to enter a particular unit.

2. Self Pacing. There is a variable amount of learning time necessary for each student to master material in an instructional unit. For some it may be only necessary to quickly review the material. Even when the learning events are a new experience for all students, learning rates will differ. The fast-paced learner will be able to expand his goal to include the progressively more difficult chapters in the core units.

3. Methods of Instruction:

   a. Individualized programmed instruction. The critical chapters in each unit are identified by the instructor. All students are expected to be able to complete these chapters.

b. Lecture. The instructor highlights learning objectives in the core units, utilizes various media to illustrate major points and stimulates discussion.

c. Laboratory projects are closely related to lecture and give students an opportunity to practice skills in small groups using test equipment and troubleshooting procedures on electrical/mechanical equipment and systems.

d. Demonstrations. When laboratory projects are not practical the instructor will demonstrate maintenance principles and practices using the college facility and machine shop equipment and other industry donated equipment and materials.

e. Field visits to various local industries.

f. Field laboratory. The student will perform tasks at the job site that develop skills associated with the core units of instruction.

4. Alternative Goals of Students

Students in the course are at various stages in their careers. For the more experienced worker, the course goal may be to gain some formalized training in theory and practice offering a refinement of skills developed over the years. For others the training offers the opportunity to develop skills in new areas of responsibility; to begin to broaden their skill base to qualify for promotion or an increase in wages. The course provides the opportunity for a broad range of goal attainment. In the core units a progressive degree of complexity and difficulty is built up in successive learning events within each unit. The student need only to progress to a level that satisfies his individual goal.

5. Feedback. Informing the student of how well he is doing throughout the learning process is done with self-administered progress tests in the programmed instruction. Classroom discussion and instructor/supervisor monitoring of laboratory projects are other direct means of feedback to the student.

6. Mastery Learning. Not all students need to learn the same subjects at the same level of mastery. In the core course the instructor identifies critical learning outcomes that provide a base for group mastery. Beyond this base individual goals determine which subjects and level of mastery are expected for that student.

7. Remediation. Students who are experiencing difficulty in responding to the progress tests with correct answers and are not mastering parts of the course to the desired criterian level of performance will require remediation. The instructor may suggest for instance a module on basic mathematics or refer the student to a lower level presentation of information on the same subjects.

   Restudy may be in the form of a simple field laboratory project to provide the individual a learning event that will increase his level of performance.

B. Specific Skill Area

1. Entry behavior. Is not appropriate for specific skill development. The individual's program is developed from a student's given skills and interest and requires no prerequisites.

2. Self pacing. Individual program is designed within the time frame determined by students' pace and speed of learning.

3. Methods of Instruction:

   a) individualized programmed instruction
   b) peer tutoring
   c) instructor tutoring
   d) inhouse and field laboratory projects
   e) OJT

4. Alternative goals of students are met in the planning of an individual program.

5. Feedback is achieved through self-administered progress test, in peer and instructor tutoring and instructor/supervisor monitoring field projects and on-the-job training.

6. Mastery Learning. Level of mastery will be determined by individual student goal.

7. Remediation. Same as described in core units of course.

C. Counseling

The unique structuring of the course requires an understanding of the educational philosophy by the student and his supervisor. Student preconceived ideas and company policies towards a more traditional approach to learning need to be broached in an initial interview. The instructor educates the student and his supervisor to regard the training as:

1. Non-threatening

a) Pre-testing is used to determine what skills the student is competent in and to indicate individual skill areas that require further development. As a guide to the instructor, testing determines what level the course should be taught and common subject area needs that can be emphasized in lecture or with other instructional media.

b) Competition is not between students. The student competes against a standard that is set from his declared goals, an assessment of his/her needs and the progress made from this starting point.

c) Progress testing in the programmed instruction is self administered. The student proceeds to the next unit when he is satisfied that he can answer feedback questions correctly. It is the student's responsibility to bring to the instructor's attention problems incurred in working through individualized units.

2. Achieving Skill Competency is demonstrated in laboratory and maintenance projects performed on the job site as part of the field laboratory. Assessment is not on how quickly the skills are learned or the theoretical knowledge associated with the skill.

   Basic orientation of the course is to develop competency in practical skill application.

3. Flexible. The course design allows the supervisor to anticipate technological developments within his company and reflect these changes in the training needs of employees by suggesting additional modules or units. Within the course parameters, instructional units can be added for individuals or tailored to a company's unique employee group.

4. Grading. The pilot course is based on a pass/fail grading system. Student participation is all that is required. However, if company policy for training cost reimbursement is depended on a letter grade, special arrangements can be made with the instructor to provide a letter grading system. The emphasis is on students assuming responsibility for their training in acquiring new skills or upgrading present skills. Dedication towards this aim is demonstrated by their attendance of 6 hours a week at the college and finding time at home to work on the self-paced materials. Most maintenance personnel work a 50 hour week minimum. Participation alone indicates a high motivating factor.

5. Interviews. Interviews with supervisors and prospective students is scheduled when a company has indicated interest in the course and returned the training assistance form and subject matter/employee interest matrix.

   The interview will cover the following points:

   - Company expectations from the course.
   - Unique training requirements for special equipment, company expansion and automation, technological developments.
   - Evaluation of skill resources within present maintenance personnel.
   - Promotion opportunities if any for employees who upgrade or acquire new skills.

- Employee transfers from other departments into maintenance.

- Tuition reimbursement policy and cost to student.

- Student goal clarification: at present company, career goals, course goals.

- Individualized instructional program outline for each student.

- Time commitments in achieving objectives discussed.

- Company commitment to provide time on the job for field projects.

IV. INSTRUCTIONAL MEDIA

A. Programmed Instruction
B. Text
C. Audio Visuals
D. Equipment and Laboratory Materials

IV. INSTRUCTIONAL MEDIA

Instructional media is defined as any means of presenting instructional material to the learner. The electrical/mechanical course used the following classifications of media:

1. Programmed instruction.
2. Textbooks.
3. Lecture
4. Demonstration
5. Audio recordings
6. Film
7. Still visual
8. Real objects
9. Simulated systems

It is this combination of media that offers a variety of means in which learning can take place. Research has shown that some students respond better to some instructional treatments over others. In an ideal situation optimal effectiveness could be obtained by selecting the most effective media for each student individually. Since this is not practical, a number of mediums are offered to cover the same learning objectives for that unit. This assures that all students will find a medium which is most effective for that individual. The student will find reinforcement of the learning outcomes in the other media. Primarily the selection of media was determined by offering the best possible instruction for a specific subject matter.

Rationale in the selection of media included a consideration of the following characteristics:

1. Learner characteristics:

   a. Students are all adults employed in maintenance. Most have not been in a learning environment for many years.

   b. Entry skills varied with some students working in electrical and wanting upgrading and cross training in mechanical. Other students were primarily mechanics who wanted to acquire new skills in electrical maintenance.

   c. Level varied from apprentice to near journeyman.

2. Consideration of the main course objective: to develop skill competency rather than emphasize theoretical knowledge.

3. The instructional model: group and individualized instruction inhouse and field laboratory.

4. The instructional objectives: identifying the "best" media for presenting each learning event.

5. Media characteristics:

   a) Cost to students (limitation of $20 per student was requested by one company.)
   b) Complexity and presentation of information.
   c) Availability and ease of production.
   d) Effectiveness

6. Systems Constraints:

a) Budget did not allow purchasing materials or new equipment with the exception of a Kemfe Training Center to be used in other laboratory courses at San Jose City College.

b) Time was extremely limited. Normal development time for a course of this complexity is 2 years. The pilot was developed in 5 months.

c) Human resources: An instructor was hired 2 weeks prior to class start. Proposition 13 and organizational changes caused continual turnover in human resources.

d) Political and social climate.

e) Learning environment: Space for laboratory was extremely limited.

INSTRUCTIONAL MEDIA

A. Programmed Instruction

The individualized instructional units in the materials package of this report are far more than any one student could complete during the 16 weeks of the course. The units are programmed so that the more experienced person can refresh his knowledge of basics by moving quickly through this material, and be stimulated with new information in the programming of more difficult material. The beginning student is expected to be able to complete only those units that will give him/her a conceptual knowledge of principles of operation and theory and limited skill development on specific devices.

Core units of course include selections from:

Paul E. Trejo, "DC Theory" and "AC Circuits", Westinghouse Learning Corporation, Cambridge Book Company, 1972.
Navpers, Programmed Instruction, Naval Air Technical Command, Long Beach, California, 1979.
TPC Training Systems, Maintenance Fundamentals, Electrical Maintenance, Mechanical Maintenance, Technical Publishing Company, 1979.

Specific skill area:

The generosity of the apprentice school at the Long Beach Naval Shipyard and Mr. Walter Langosch of TPC in donating complete sets of self-study programs gave us the opportunity of offering a wide variety of lessons for individual student referral.

INSTRUCTIONAL MEDIA

B. Textbook

Selections are made from the following textbooks and documented in the course objectives section for each unit:

Edward F. Driscoll, Industrial Electronics Devices, Circuits and Applications. American Technological Society, Chicago, 1976.
James E. Adams, Electrical Principals and Practices. McGraw-Hill Book Company, Novato, California, 1973.

Additional reference material was drawn from the following texts and used as suggested reading to meet individual student goals:

Clyde N. Herrick, Electrical Wiring Principals and Practices, Prentice Hall Inc., Inglewood Cliff, New Jersey, 1975.
U. S. Government Printing Office, Basic Electricity, 1967.
Harry Mileaf, Electricity Six and Electricity Seven, Hayden Book Company, New Jersey.

Textbooks are an auxiliary media to individualized instruction. It is also a useful reference as students gain more experience on the job and are given complex equipment, devices or systems to maintain.

3.C. Audio Visuals

Navy training films in basic electricity were drawn from the film library at the Naval Air Station, Moffett Field. Authorization for use of the films was given by John R. Shackleton, Public Affairs Officer.

Slide tapes and audio tapes on Wire Diagrams, single phase and three phase motors were lent to the pilot course by Dave Fleckless, Regional Vocational Center, San Jose.

(*We would like to thank Mr. Shackleton and Mr. Fleckless for their cooperation.)

Films U.S. Navy

MN 15400 Elementary Electricity, Amps, Volts, Ohms Law
MN 1540V Elementary Electricity, Series and Parallel Cirucits
MA 2333B2 Ohms Law
MN 8016A Electron Theory
MN 8016B How Magnets Produce Electricity
MN 8016D Electromagnets
MN 8018A AC Series Circuits
MN 8018D AC Parallel Circuits
Electrical Safety: 115V Deadly Shipmate

D. Equipment and Laboratory Materials

Equipment used in classroom demonstrations was donated by local companies and included: motors, transformers, semiconductor devices, industrial lighting components, specification sheets, industrial manuals, charts, brochures and installation instructions, power supply, starters and controllers, resistors, relays and switches.

Demonstrations were also performed on equipment and systems maintained by San Jose City College personnel. These included air conditioning system, lighting system, emergency lighting system, pumps, motors, controllers for machine shop equipment, sub station panels, power supply panels.

A Kemfe training center was purchased to simulate electrical problems. Students can diagnose and troubleshoot various simulated conditions. Devices such as controllers, motors, pumps can be interfaced to the unit to provide a systems approach to problem solving.

Equipment and materials from the electronics laboratory was used by the students in the machine shop. These included VOM, clamp on ampmeters, voltmeters, power supply, resistors, resistors board, electronics board, various test boards, leads, oscilloscope, sine/square and generator.

Test equipment to be brought in by the students from their place of employment may include: multimeter, megger, wiggies, AC and DC, low impedence voltage tester, continuity checker, audio oscillator, ground fault tester, phase sequence indicator, phase rotation indicator.

Other equipment and materials from the job site would include schematics and wire diagrams, motors, control devices, protective devices and any portable equipment maintained by maintenance.

FORWARD TO UNIT OBJECTIVES

The industrial companies from which the students are drawn have on their premises a wide variety of electro-mechanical devices.

During the course of this pilot program, attempts are being made to obtain samples for classroom use of as many of these kinds of devices (through donations) as possible. This also applies to test instruments.

The Unit Objectives as outlined in the following pages provide conceptual knowledge of the theory of operation and skill development of maintenance practices for many of these industrial devices. The practical application of these theories and maintenance techniques (hands on) will depend on the cooperation of the employer companies in furnishing, where possible, devices and test instruments for classroom laboratory use. When this is not possible, the employer will make available in field laboratory opportunities to apply skills from classroom theory to the actual device.

During this 16 week program, it is unlikely that each student will be able to put their "hands on" each type of device discussed or demonstrated in the classroom. The primary goal of making the student more competent in maintaining the equipment found everyday on the job will be met if the student is given the opportunity to apply the theory shortly after the learning event when the devices become available at the work place.

The philosophy of maintenance as performed by industry today is to effect the repair at the lowest cost/time. This usually involves replacement rather than repair of components since it is faster and less expensive to do so particularly if the failed equipment stops a production line. The maintenance man primarily requires skills to quickly isolate faulty equipment and replace it. The Units Objectives as described in the following pages are designed to give the student a general knowledge of the theory of each type of device or system and how to use test instruments and aids to diagnose problems. When these devices become available, the student will perform the calculations, make the measurements, repair or make replacements in a systems environment.

V. COURSE OBJECTIVES

A. BASIC ELECTRICITY *Laboratory

Unit Objectives DC Theory

The student will be able to:

1. Define the principles of voltage, current, resistance.
2. Perform calculations for voltage, current and resistance using Ohms law formula.
3. Use electrical test instruments to measure voltage, current and resistance and verify calculations.
4. Make calculations for series and parallel DC circuits.
5. Define the principles of magnetism, electromagnetism and inductance.
6. Define the theory of capacitance and perform related calculations.

*To monitor performance the students are given components and circuit diagrams with which to build a circuit, perform the theoretical calculations for the circuit, parameters of voltage, current and resistance and then the student is required to use test instruments to verify the calculations.

Instructional Materials

Programmed Instruction: Introduction to Electrical Symbols. Naval Air Technical Training Command.

DC Theory, Paul Trejo, Westinghouse Learning Corporation.
Laboratory Experiments: Assigned as required.

JSI-A1	Use of Ohmmeter
JSI-B2	DC Current measurement
JSI-B3,4	Measuring DC potentials
JSI-C2,3	Measuring DC potentials and current
JSI-A6	Circuit translation

Hand outs: color code and Ohms law. Samples of color coded components. Instructor written problems for Ohms law calculation practice on series and parallel DC circuits.

Film	US Navy
MN 1540U	Elementary Electricity. Amps, Volts, Ohms Law.
MN 1540V	Elementary Electricity. Series and parallel circuits.
MA 2333B2	Ohms Law

Unit Objectives AC Circuits

The student will be able to:

1. Describe AC sine wave voltage generation.

2. Perform the calculations for peak, average and effective levels of a AC sine wave.

3. Perform the calculations related to inductive reactance in AC circuits.

4. Perform the calculations related to capacitive reactance in AC circuits.

5. Explain impidence in AC circuits and how it compares to resistance in a DC circuit. Perform the calculations for impedence in AC circuits.

6. Explain the difference between true power and apparent power and calculate power factor.

7. Distinguish between 1,2 and 3 phase AC power distribution. Explain the difference between Delta and Wye connections and the voltages associated with each.

*Perform measurements on AC circuits with low grid high impedence AC voltmeters, wiggy testers and oscilloscopes.

Instructional Materials

Programmed Instruction:

Electromagnetic Devices, Generators,

P-VI-1R, US Navy, Naval Air Technical Training Command

AC Circuits, Paul Trejo, Westinghouse Learning Corporation

TPC Electrical Measuring Instruments

Lesson 5 AC Measurements

Lesson 8 Indicating Instruments

Lesson 10 Electronic Instruments

Laboratory Experiments:

JSI E4 Loading Effect

JSI F1 Oscilloscope

JSI F2 Oscilloscope

JSI F3 DC and AC Measurements

Film: US Navy

MN 8016A Electron Theory

MN 8016B How magnets produce electricity

MN 8016D Electromagnets

MN 8018A Inductance in AC circuits

MN 8018C AC Series Circuits

MN 8018D AC Parallel Circuits

Unit Objectives — Motors

The student will be able to:

1. Explain the basic differences between AC and DC motors and generators, commutators and slip rings, and identify component parts.

2. Describe principles of motor operation for the four most common types of AC single phase, synchronous, induction, universal and repulsion.

3. Perform maintenance and trouble shooting techniques on single phase AC and DC motors. Demonstrate on available equipment.

* Use test equipment common in motor repair such as megohmeter, growler.

5. Identify the starting and protection devices used with single phase motors.

* Dismantle AC and DC motors identifying the internal construction and use test instruments to measure winding continuities. Identify slip rings, commutators, brushes, etc.

Field Trip

Tour of manufacturing plant. Reinforce classroom lectures with samples of motor construction.

6. Describe how to reverse the direction of rotation in AC and DC motors. Use maintenance demonstration unit to verify knowledge.

Instructional Materials

Text: Electrical Principles and Practices, James E. Adams, Prentice Hall, Chicago.

Chapter 9 DC Motors
Chapter 11 Commutators and Brushes
Chapter 12 DC Motor Controls
Chapter 13 DC Generators
Chapter 15 Single Phase Motors

Text: Electricity Six, Power Sources, Harry Mileaf, Hayden Book Company, New Jersey.

Programmed Instruction: TPC Single Phase Motors

Lesson 1 Operating Principles
2 Split Phase Motors
3 Capacitor Motors
4 Repulsion Motors
5 Universal Motors
9 Starting and Protection
10 Motor Maintenance

Visuals: Various overhead projection transparencies on motor and generation construction.

Slide tape single phase and 3-phase motors

Unit Objectives — Power Supplies

The student will be able to:

1. Describe power transformer construction and theory of operation.

2. Perform calculations for voltage, current and turn ratios and impedence mathing of transformer windings.

3. Describe AC rectification and the ripple frequencies resulting from half and full wave rectifers.

* Use an ohmmeter to test silicon diodes for front to back ratio.

4. Isolate malfunctioning components in power supply filter circuits and replace foiled capacitors and inductors.

* Perform calculations and make confirming measurements on AC to DC power supplies.

Use test instruments to locate faults. Adjust output levels, adjust voltage regulation of AC to DC power supply devices.

5. Describe the theory of DC to AC investers. Locate faults and replace failed components. Measure and adjust output levels.

6. Describe the theory of DC to DC power supplies. Locate faults and replace failed components. Measure and adjust output level.

7. Describe the theory of AC to AC power supplies. Locate faults and replace failed components. Measure and adjust output levels.

8. Troubleshoot voltage regulator circuits found in industrial power supplies.

9. Identify types of semiconductor devices used in industrial power supplies.

*Use test instruments to find defective semiconductor devices.

Instructional Materials

Programmed Instruction: TPC Power Supplies

Lesson 1 Introduction to Power Supplies
2 Rectifiers
3 Filters
4 Voltage Regulators
5 Troubleshooting
TPC Transformers and AC Circuits
Lesson 8 Transformer Theory

Visuals: Varios transperancies for overhead projector showing transformer windings.

Unit Objectives — Equipment and Controls

The student will be able to:

1. Explain the theory of operation of the following industrial control devices: switches, timers, solid state controls, magnetic amplifiers, thermo electric devices, photoelectric devices.

* The student will identify the types of devices (from the catagories in (1) above, that are used at his place of employment. The student will learn to adjust those types of devices (set limits, timers, etc.) and use test equipment to locate faults in failed equipment.

Instructional Materials

Text: Industrial Electronics, Edward Driscoll, McGraw-Hill

Chapter 1 On-Off Switching Devices
2 Timers
3 Power Tubes and Solid State Control
4 Saturable Reactors and Magnectic Ampliphiers
5 Thermo Electrics
6 Photo Electrics

Programmed Instruction: TPC AC Control Equipment

Lesson 1 Motor Starters
2 Pushbutton Control Stations
3 Limit Switches
4 Special Control Switches
5 Timers and Counters
6 Control Relays
7 Hazardous Location Equipment
8 Special Motor Control
9 Motor Control Centers
10 Control Panel Wiring

Unit Objectives — 3 Phase Applications

The student will be able to:

1. Describe 3 Phase power distribution techniques from the service entrance (power company transformer) to the power distribution panels.

2. Describe the differences between single phase and 3 phase AC motors.

3. Explain the principles of operation of 3 phase induction motors, synchronous motors, and multiple speed motors.

4. Use a phase sequence indicator and phase rotation meter to determine the proper way of connecting 3 phase equipment to the power source.

5. Describe the principles of AC motor starting and the devices used for reducing starter currents.

* Locate faults in starter circuits using Kemfe electrical training center in the classroom.

Instructional Materials

Programmed Instruction: TPC Three Phase Systems

Lesson 1 Three phase motor principles
2 Induction motors
3 Synchronous motors
4 Multiple speed motors

5 3 phase motor maintenance
6 AC motor starting principles
7 3 phase motor controllers
8 3 phase alternators
9 Auxillary Generators
10 Power Distribution Systems

Text: Electrical Principles and Practices, James E. Adams, Prentice Hall
Chapter 16 3 Phase Motors
17 AC Motor Controls
18 Transformers

Text: Electricity Seven, 3-Phase Motors, Harry Mileaf, Hayden Book Company, New Jersey

Unit Objectives — Lighting and Distribution

The student will be able to:

1. Describe the basic principles of lighting and perform related calculations.

2. Explain the differences in incandescant, flourescent, and gas vapor lighting.

3. Perform calculations for lighting power distribution. Draw schematics.

* Inspect the internal parts of a flourescent lamp fixture and identify the components. Do the same for a mercury vapor lamp fixture. Discuss the principles of Arc-discharge lighting.

* Students bring in diagrams for lighting circuits at their place of employment and identify the schematic symbols and other data showing their ability to interpret these diagrams.

Instructional Materials

Programmed Instruction: TPC Electrical Protective Devices
Lesson 9 Industrial Illumination
7 Electrical Calculations

Unit Objectives — Safety-Electrical

The student will be able to:

1. Observe the general principles of electrical safety.

* Each student is to learn of any unusual or specific electrical safety requirements used at this company and describe these in class.

* Each student should know the method used at his company for tagging circuit breakers or other disconnects before working on equipment. Describe these procedures in class.

Instructional Materials

Programmed Instruction: TPC Electrical Protective Devices
Lesson 10 Maintenance and Safety

AC Theory, Paul Trejo, Westinghouse Learning Corporation
Safety Guidelines

Text: Basic Electricity, US Navy, NAVPERS 1 GJ 86-A
Chapter 21 Safety

Film: 115V Deadly Shipmate

Unit Objectives Preventative Maintenance Procedures, Schedules

* Students are to familiarize themselves with the PMI routines for electrical equipment that are used at their place of employment. The student shall bring to class in outline form a synopsis of the maintenance paper work system used at their respective companies.

B. MECHANICAL *asterisk indicates laboratory project

Unit Objectives Basic Mechanics

The student will be able to:

1. Describe "force" and the standards used to measure force FPS and MGS.
2. Explain static and dynamic equilibrium.
3. Describe tension, compression, and torque.
4. Describe motion, velocity, acceleration, and perform calculations related to each.
5. Explain potential and kinetic energy.
6. Perform calculations for work problems.
7. Describe the principles of the six simple machines: lever, wheel, axles, pulley, incline plane, and wedge.
8. Use blueprints/schematics in troubleshooting mechanical systems.

Instructional Materials

Programmed Instruction: TPC Elements of Mechanics.
Lesson 1 Forces
2 Motion
3 Work and Energy
4 Simple Machines

Various transparencies showing mechanical principles.

Unit Objectives — Bearings

The student shall be able to:

1. Describe the uses of plain journal bearings.

* The student shall locate devices at his company that use plain journal bearings and describe them in class.

2. Use measuring instruments (micrometers, calipers, etc.) to determine proper replacement sizes for worn bearings.

3. Describe the uses of anti-friction bearings.

* The student shall locate devices at his company that use anti-friction bearings and describe these in class.

4. Remove and replace worn bearings with the use of bearing pullies, arbor press, and other appropriate tools.

5. Diagnose and correct bearing trouble conditions.

6. Select and apply the correct lubricant for a given bearing application.

Instructional Materials

Programmed Instruction: TPC - Bearings

Lesson	1	Principles of Bearings and Shafts
	2	Plain Journal Bearings I
	3	Plain Journal Bearings II
	4	Anti-Friction Bearings I
	5	Anti-Friction Bearings II
	9	Lubrication
	10	Bearing Maintenance

AAVIM Ball & Roller Bearings.

Unit Objectives — Lubrication

The student shall be able to:

1. Define common lubrication terms such as: rolling friction, sliding friction, etc.

2. Describe the six basic purposes of lubrication.

3. Explain the properties of lubricants.

4. Select the proper lubricant for the temperature and application.

5. Use manual lubricating tools and techniques.

6. Service automatic lubricating systems.

* The student shall determine what type (if any) of automatic lubricating systems are at this plant and describe these in class along with a discussion of proper service techniques.

7. Describe proper storage techniques for lubricants and safe handling practices.

Instructional Materials

Text: Powers Handbook on Bearings and Lubrication.

Programmed Instruction: TPC - Lubrication.

Lesson 1 Principles of Lubrication
2 Lubricant Characteristics
3 Additives, Lubricating Action and Bearing

Lubrication.

4 Oils and their Applications
5 General Purpose Greases
8 Lubrication Systems and Methods
9 Automatic Systems
10 Lubricant Storage and Handling

Unit Objectives: Drive Components

The student shall be able to:

1. Assemble/disassemble and perform required maintenance on mechanical drive components such as:

    a. Solid couplings
    b. clutches
    c. V-belt drives
    d. chain drives

* The student shall locate examples of these various drive components around his plant and describe the uses in class.

2. Describe the principles of mechanical and electrical speed reducers.

* The student shall locate examples of speed reducers at his plant and describe the uses in class.

Instructional Materials

Programmed Instruction: TPC - Drive Components

Lesson	1	Common Couplings
	3	Clutches
	4	V-belts
	5	Chain Drives
	6	Speed Reducers I
	7	Speed Reducers II

Unit Objectives — Pumps

The student shall be able to:

1. Assemble/disassemble and perform required maintenance on the various types of pumping systems used at his company.

* The student will identify the types of pumps used around the plant and learn the theory of operation and maintenance routines for each type.

2. Define terms associated with pumps such as, suction lift, suction head, total static head, etc.

3. Perform calculations associated with pumps, such as velocity head and friction loss for water, etc.

4. Diagnose pump malfunctions and take corrective action.

Instructional Materials

Programmed Instruction: TPC - Pumps

Lesson 1 Pump Applications
2 Pump Selections
3 Centrifugal Pumps
4 Propeller and Turbine Pumps
5 Rotary Pumps
6 Reciprocating Pumps
7 Metering Pumps
8 Special Purpose Pumps
9 Packing and Seals
10 Pump Maintenance

Unit Objectives Safety Mechanical

The student will be able to:

1. Describe the basics of safety around mechanical equipment.

2. Handle heavy mechanical assemblies in a safe, efficient manner.

* The student shall identify equipment around his company used for handling, transporting, installing, large assemblies, such as chain hoists, portable gantrys, fork lifts, etc. and be able to use the items in a safe workmanlike manner. Describe protective clothing and other safety devices.

Instructional Materials

Specific safety instructions from industry:

Chemicals	Propellants
Toxic materials	High pressure vacuum
Flammable materials	Safety showers
Material handling equipment	

Facilities inspection checklist:

Shop safety
Fire protection
Compressed gas area
Laboratories, etc.

Official safety checklist from:

Company safety management
Fire department and their city officials
State officials

VI. FIELD LABORATORY

A. Description

B. Project Suggestions

VI. FIELD LABORATORY COMPONENT

Field Laboratory Description

	Weekly	Course Total
Employee - Selected Projects	4 hrs./wk.	48 hours
Supervisor - consultation	1 hr./2 wks.	8 hours
Instructor - on site visits	1 hr./2 wks.	8 hours

Field laboratory is designed to take greatest advantage of the equipment and various components within an industrial system that require maintenance activity. Students will participate in their department preventative maintenance procedures, routine maintenance, breakdown repairs and special plant engineering projects.

Although field laboratory uses the administrative mechanics of the work experience cooperative program in operation at San Jose City College (Figures 10 and 11) it differs in many respects:

1. The coordinator is the instructor who works with the supervisor and student to extablish individual project objectives associated with specific skills to be learned on the job. Competencies gained are assessed by instructor and supervisor. Field laboratory objectives are closely associated with a students goals which are clarified and documented in an initial counseling interview prior to the start of the course. A student profile (Figure 12) illustrates the kind of information used in assessing goals.

2. The company signs a contractual agreement to provide four hours a week during normal working hours for each student to perform his/her laboratory project under the supervision of an experienced journeyman.

3. A list of suggested projects is compiled by the instructor following a visit to the place of employment and used as a basis for discussion between employees and their supervisor to develop individual field laboratory programs. Criteria for list is:

a. Maintenance structure and responsibilities within each participating company (see company profile figure 3).
b. Type of production and facilities equipment employee is expected to maintain in his/her present job. (Example Figure 13.)
c. Parameters within which the course is to be taught as determined by level and background experience of the employees selected for training.

Field laboratory is an important component in the course. The student can apply theoretical knowledge and familiarization with test instruments and devices learned in the classroom and inhouse laboratory to real time maintenance problems encountered on the job. Skills are reinforced throughout the learning process with their timely application in industry.

ELECTRO-MECHANICAL MAINTENANCE FIELD LABORATORY
SUGGESTED PROJECTS

The following twenty Field Laboratory projects are a general list of the types of activities the student should have the opportunity to perform at his/her place of employment for on the job experience relating to the classroom lectures and demonstrations.

The supervisors at the students place of employment will of course have to tailor these general goals to the more specific requirements of the workplace. If other, comparable tasks are deemed more appropriate, the supervisor is encouraged to discuss them with the instructor so they may be included in an individual students Field Laboratory projects.

The student is expected to perform any six of these twenty projects (or similar projects recommended by the supervisor) during the twelve weeks of the field laboratory program.

1. Demonstrate knowledge of safety procedures, techniques and related equipment with regard to the electrical systems the student will be performing maintenance upon.
    a. General safety techniques for working around electrical equipment.
    b. Specific safety procedures used at the students workplace.

2. Use Power Distribution and Panel Diagrams (electrical blueprints) to locate a tripped circuit breaker. Determine the cause for the breaker to trip, and take corrective acction.

3. Draw an electrical blueprint for a new circuit or the modification of an existing circuit.

4. Demonstrate a familiarity with the common symbols used on Electrical/Electronic diagrams. Identify the actual component from the symbol on a drawing.

5. Use common electrical test instruments to diagnose an electrical equipment problem. Some examples: 1) The use of a Wiggy to locate an open fuse, 2) The use of a clamp on ampmeter to determine the current draw of a meter.

6. Perform basic electrical calculations to determine if circuit breaker sizes are adequate to power equipment additions.

7. Identify the various types of Timers used at the company and know the procedures for setting them. Types may include Thermal, Dashpot, Meter-Driven, Electronic, Electro-Chemical.

8. Identify the various Thermocouple devices used at the company. Use available test instruments to diagnose failed units and to calibrate replacement units after proper installation.

9. Perform required maintenance on recording instruments used around the plants, Strip Chart Recorders, Round Chart Recorders, etc.

10. Use Electronic test instruments to diagnose equipment problems or make level adjustments. Oscilloscopes, VTVM, Frequency Counters, etc.

11. Participate in the installation of a 3-Phase AC motor, using a Rotation Tester to tag the motor lead phases and a Phase Sequence Indicator to determane the Phase relationship of the branch circuit.

12. Install or replace an AC NEMA type Split Phase motor. Demonstrate the knowledge required to have the motor rotate in a Clockwise or Counter-Clockwise direction.

13. Perform motor maintenance as required in the following or other areas. Brush replacement, Commutator service, End play, Motor starter contacts, Capacitor replacement, Insulation breakdown testing, Lubrication.

14. Perform the required adjustments on a motor controller, such as High/Low voltage limits and current limits.

15. Demonstrate a good working knowledge of the "Maintenance Paper Work System" in use at the students company.
    a. Forms/Procedures for Preventative Maintenance, Routine Maintenance, and Trouble Call/Emergency Maintenance.
    b. Technical documentation. Plant mechanical and electrical diagrams, Instruction manuals for individual equipments and reference texts for codes and standards.
    c. Documentation necessary for purchasing, stocking, and issuing of spares required for maintenance activities.

16. Where electrical and mechanical devices are used around Caustic and Volatile materials the student should demonstrate knowledge of the practices approved at his company when maintenance is performed on this equipment. These should include an understanding of the hazards of the materials themselves and how they affect electrical and mechanical equipment as well as human health.

17. Diagnose/repair problems in electro/mechanical, electro/pneumatic and electro/hydraulic devices.

18. Perform lubrication tasks on various plant equipments using different lubrication systems, manual, gravity, splash, pressure.

19. Use a variety of tools in performance of maintenance tasks. Hand tools, and Power tools, both electric and pneumatic.

20. Select and use the appropriate fasteners for an installation or repair of equipment. Selection should demonstrate knowledge of electrolysis potential, strength of materials, proper torque where applicable.

VII. BACKGROUND DATA

VII. BACKGROUND DATA

To define specific job skills that could be programmed for instruction in electrical/mechanical maintenance, the following sources were used:

- A task analysis survey was conducted with 200 participating companies. Tasks were prioritized for importance and frequency. Employeers ranked subject area skills necessary prior to employment and those appropriate for upgrading employees skill level. Electrical and mechanical rankings are shown in Figure 1A.

- On site task observations were conducted in four industry representative firms to validate and augment the survey. Examples Figure 2. The companies are:

  Xidex Corporation
  National Semiconductor Corporation
  California Paperboard Corporation
  Baker Beech-Nut Cannery

- Company profiles were compiled including structure of the organization detailing maintenance interrelated to other departments and its importance to production and profits. Example Figure 3.

- Consultation with maintenance managers in six different industries on the job site and by telephone interview was productive for information gathering and technical advice on course content. Example Figures 4 and 5.

- Advisory Committee formed by San Jose City College to review progress and support a maintenance technician curriculum planned for development on a course by course basis over the next five years. (Committee members listed in preface.)

- Active job descriptions were collected by interview with maintenance department management from the companies' personnel department. Example Figure 6.

The parameters of the course were defined from the vast body of information gathered from the sources listed above as indicated in the course outline (Figure 7). A matrix of subject areas and employees interest ratings were mailed to 16 companies (Figure 8). The response was analyzed to find two companies whose employee skill level and interest were somewhat homogeneous representing common needs. From this data the instructor was able to tailor learning activities from the general course content to the specific needs of employees enrolling in the course.

Further refinement of content and skill level to be taught in each module was achieved by administering a pretest to students the first day of class. The pretest will also be used as one of the individual evaluation tools in assessing the effectiveness of the instructional materials in achieving skill competency. Figure 9.

Some of the material presented in this section was developed for products of the EXCITE Project: The student guidance component and task packets for curriculum in maintenance occupation. The maintenance curriculum skill areas of the EXCITE Project are: electrical, mechanical, hydraulics, and pneumatics, welding, plumbing, carpentry, millright, air conditioning, and refrigeration, instrumentation. Selection of data is made to illustrate the type of background information that is available for use in course development. Figure 1B.

VIII. FIGURES

1. A) Task Analysis Rankings by Employers in Electrical/Mechanical
   B) Survey of Tasks in Maintenance Curriculum Skill Areas
2. On-Site Tasks Observations

Available upon request:

3. Company Profile
4. Maintenance Manager Interviews
5. On-Site Interviews
6. Job Descriptions
7. Course Outline
8. Matrix of Subject Areas
9. Pre-test
10. Cooperative Work Experience Education Guidelines
11. A) Work Experience Performance Agreement
    B) Work Experience Application
12. Student Profile
13. Example of Preventative Maintenance Procedures on Industrial Equipment

Indicate with an X in one or more boxes if you feel the skill listed is of high frequency or importance for:

Column A - those skills necessary prior to employment
Column B - those skills necessary for upgrading maintenance personnel
Column C - not required.

Skills Required			
A Prior to Emp.	B Upgrading	C Not Required	Technician will be able to:
			ELECTRICITY
			1. Relate wattage to HP.
			2. Relate mechanical energy to electrical energy.
			3. Understand concepts of Ohms law and be able to apply to series and parallel circuits.
			4. Convert mechanical energy from ft. lbs. into HP.
			5. Make safe and sound judgments in lifting and moving heavy equipment based on basic laws of physics.
			6. Understand potential energy of gears, shafts, motors, etc., in order to avoid safety hazards.
			7. Identify electrical malfunctions in electrical circuits with VOM or machine instrumentation such as troubleshooting to PCboard level.
			8. Identify and troubleshoot electrical components such as relays, fuses, circuit breakers, motor starters, switches, solenoics, coils and power supplies.
			9. Identify electrical malfunctions of transformers.
			10. Understand principles of AC and DC motors for preventative maintenance and to be able to work with electrician to identify electrical and mechanical failures.
			11. Field repair and install AC and DC motors.
			12. Install outlets for lighting, wall switches and receptables.
			13. Bend EMT (electrical metallic tubing) or thin wall conduit.
			14. Work with rigid metal conduit.
			15. Utilize the current national electical code.

Skills Required

A Prior to Emp.	B Upgrading	C Not Required	Technician will be able to:
			16. Install romex cable types NM and NMC.
			17. Read electrical symbols from a blueprint and interpret electrical symbols as recognized by the American national standards.
			REFRIGERATION AND AIR CONDITIONING
			18. Silver braze and solder with oxygen-acetylene and air-acetylene torches.
			19. Identify by name and function the basic components of a refrigeration and air conditioning system.
			20. Leak check a refrigeration system with soap bubbles, Presto-lite leak detector and electronic leak detectors.
			21. Evacuate a system by using a two-stage vacuum pump with a micron vacuum gauge.
			22. Install a refrigeration manifold to a service valve system as well as a schrader valve system.
			23. Charge a refrigeration system by sight glass method, condenser temperature difference method, frost line method and amperage draw method.
			24. Diagnose mechanical refrigeration malfunctions and properly repair.
			25. Troubleshoot and repair single phase and three phase compressor electrical systems.
			26. Draw and interpret schematic and pictorial electrical diagrams.
			27. Determine heat loads on commercial refrigeration fixtures.

Skills Required

A Prior to Emp.	B Upgrading	C Not Required	Technician will be able to:
			28. Select necessary equipment, accessories and piping to install a refrigeration system.
			29. Determine heat loads for air conditioning and heating on residential and commercial buildings.
			30. Diagnose and service ice machines, such as Scotsman, Cold-Draft, Whirlpool and Frigidaire.
			31. Size and design hot and chilled water air conditioning systems as well as condenser water systems.
			32. Size and design air distribution systems.
			33. Do air analysis on a psychrometic chart.
			34. Read and interpret mechanical system blueprints.
			35. Identify and service pneumatic, electronic and electric controls.
			MECHANICAL MAINTENANCE
			36. Select and use correct hand tools such as hammers, chisels, files and other common tools.
			37. Use torque wrenches.

Skills Required			
A Prior to Emp.	B Upgrading	C Not Required	Technician will be able to:
			38. Select and use special tools such as pin wrenches, impact wrenches, gear pullers, snap ring pliers, drifts, and make special tools for removing gears, bearings and seals.
			39. Do drilling and tapping (hand grinding of drills).
			40. Use all basic measuring tools such as micrometer scales, indicators, verniers.
			41. Use tachometers.
			42. Select the correct fasteners according to the tensile strength of the fastener.
			43. Insert heli-coils.
			44. Scrape bearings.
			45. Fit tapered pins of keys; i.e., cotter, straight, woodruff.
			46. Assemble gearing of shafts with correct clearance.
			47. Fit gibs to pulley shafts and check alignment of pulleys.
			48. Fit and adjust tension on vee belts and timing belts.
			49. Balance (dynamic and static) shafts and pulleys.
			50. Select bearings from catalogs.
			51. Assemble bearings by fits, tolerances and alignments.
			52. Select the correct lubrication for bearings.
			53. Fit seals and shields when assembling bearings.
			54. Identify applications for radial and axial load on bearings.
			55. Maintain and troubleshoot bearings by identifying cause of failure.
			56. Service automatic lubrication.
			a. Check gauges.
			b. Check sight glasses.

Skills Required

A Prior to Emp.	B Upgrading	C Not Required	Technician will be able to:
			c. Check oil for contamination.
			d. Check automatic pumps, needle valves, cams.
			57. Select from service charts types of greases and oils for servicing a particular piece of equipment and cross reference for types of lubricants.
			58. Align couplings using indicators, straight edges, pieces of string.
			59. Assess foundations for suitability of installation considering vibrations, shimming and the correct use of rubber absorbers.
			60. Align pumps indicating the shafts and faces for squareness and co-axiallity of spindles or shafts.
			61. Read blueprints and sketch schematics.
			62. Perform basic shop mathematical functions such as speeds, eeds, tap drill sizes, areas, volumes, etc.

Skills Required

A Prior to Emp.	B Upgrading	C Not Required	Technician will be able to:
			PLUMBING
			63. Open clogged drains mechanically (using plunger and plumber tools), chemically, hydraulically and do preventative maintenance.
			64. Maintain pumps.
			a. Repack pumps, install couplings and align pumps.
			65. Overhaul pumps by disassemble, remove/install bearings, shafts impellers and packing and install mechanical seals.
			66. Repair pipes by excavation, shoring to OSHA standards, pipe coupling and clamp repair, roustabout and back-filling.
			67. Install sinks and lavatories.
			68. Change washers, fitters and screens on fixtures.
			69. Sweat a copper connection.
			70. Properly install PVC and ABS plastic pipe.
			71. Reset water closets, flush valve or flush box type.
			72. Read a plumbing diagram.

Skills Required

A Prior to Emp.	B Upgrading	C Not Required	Technician will be able to:
			CARPENTRY
			73. Make and repair formica counter tops.
			74. Make and repair work benches.
			75. Construct interior partitions and install manufactured portable partitions.
			76. Build and install shelves and small wall hung cabinets using machine wood working equipment.
			77. Install and maintain locks, hinges, and dead bolts.
			78. Rehang a door.
			79. Install acoustical tile.
			80. Install, tape, texture and paint drywall.
			81. Prepare and paint interior and exterior surfaces.
			82. Repair broken windows.
			83. Read blueprints, interpreting symbols and dimensions.

QUESTIONNAIRE

1. Total number of employees at your facility: _____

2. Total number of maintenance personnel. Name specific job titles and indicate how many for each.

3. Projected increase for 1 year _____, 3 years _____.

4. Expected replacements for 1 year _____, 3 years _____.

5. Are you providing in-house training for maintenance personnel? If so, explain:

6. Are your main personnel members of unions or labor organizations? If so, please list:

7. What technological advancements do you anticipate that may affect the:

   a) Requirements for employing maintenance personnel;

   b) Requirements for training;

   c) Job description.

   Please explain:

8. Would you be interested in providing further guidance in the development of this program?

Indicate with an X in one or more boxes if you feel the skill listed is of high frequency or importance for:

Column A - those skills necessary prior to employment
Column B - those skills necessary for upgrading maintenance personnel
Column C - not required.

Skills Required

A Prior to Emp.	B Upgrading	C Not Required	Technician will be able to:
			ELECTRICITY
			1. Relate wattage to HP.
			2. Relate mechanical energy to electrical energy.
			3. Understand concepts of Ohms law and be able to apply to series and parallel circuits.
			4. Convert mechanical energy from ft. lbs. into HP.
			5. Make safe and sound judgments in lifting and moving heavy equipment based on basic laws of physics.
			6. Understand potential energy of gears, shafts, motors, etc., in order to avoid safety hazards.
			7. Identify electrical malfunctions in electrical circuits with VOM or machine instrumentation such as troubleshooting to PCboard level.
			8. Identify and troubleshoot electrical components such as relays, fuses, circuit breakers, motor starters, switches, solenoics, coils and power supplies.
			9. Identify electrical malfunctions of transformers.
			10. Understand principles of AC and DC motors for preventative maintenance and to be able to work with electrician to identify electrical and mechanical failures.
			11. Field repair and install AC and DC motors.
			12. Install outlets for lighting, wall switches and receptables.
			13. Bend EMT (electrical metallic tubing) or thin wall conduit.
			14. Work with rigid metal conduit.
			15. Utilize the current national electical code.

Skills Required

A Prior to Emp.	B Upgrading	C Not Required	Technician will be able to:
			16. Install romex cable types NM and NMC.
			17. Read electrical symbols from a blueprint and interpret electrical symbols as recognized by the American national standards.
			REFRIGERATION AND AIR CONDITIONING
			18. Silver braze and solder with oxygen-acetylene and air-acetylene torches.
			19. Identify by name and function the basic components of a refrigeration and air conditioning system.
			20. Leak check a refrigeration system with soap bubbles, Prestolite leak detector and electronic leak detectors.
			21. Evacuate a system by using a two-stage vacuum pump with a micron vacuum gauge.
			22. Install a refrigeration manifold to a service valve system as well as a schrader valve system.
			23. Charge a refrigeration system by sight glass method, condenser temperature difference method, frost line method and amperage draw method.
			24. Diagnose mechanical refrigeration malfunctions and properly repair.
			25. Troubleshoot and repair single phase and three phase compressor electrical systems.
			26. Draw and interpret schematic and pictorial electrical diagrams.
			27. Determine heat loads on commercial refrigeration fixtures.

Skills Required

A Prior to Emp.	B Upgrading	C Not Required	Technician will be able to:
			28. Select necessary equipment, accessories and piping to install a refrigeration system.
			29. Determine heat loads for air conditioning and heating on residential and commercial buildings.
			30. Diagnose and service ice machines, such as Scotsman, Cold-Draft, Whirlpool and Frigidaire.
			31. Size and design hot and chilled water air conditioning systems as well as condenser water systems.
			32. Size and design air distribution systems.
			33. Do air analysis on a psychrometic chart.
			34. Read and interpret mechanical system blueprints.
			35. Identify and service pneumatic, electronic and electric controls.
			MECHANICAL MAINTENANCE
			36. Select and use correct hand tools such as hammers, chisels, files and other common tools.
			37. Use torque wrenches.

Skills Required

A Prior to Emp.	B Upgrading	C Not Required	Technician will be able to:
			38. Select and use special tools such as pin wrenches, impact wrenches, gear pullers, snap ring pliers, drifts, and make special tools for removing gears, bearings and seals.
			39. Do drilling and tapping (hand grinding of drills).
			40. Use all basic measuring tools such as micrometer scales, indicators, verniers.
			41. Use tachometers.
			42. Select the correct fasteners according to the tensile strength of the fastener.
			43. Insert heli-coils.
			44. Scrape bearings.
			45. Fit tapered pins of keys; i.e., cotter, straight, woodruff.
			46. Assemble gearing of shafts with correct clearance.
			47. Fit gibs to pulley shafts and check alignment of pulleys.
			48. Fit and adjust tension on vee belts and timing belts.
			49. Balance (dynamic and static) shafts and pulleys.
			50. Select bearings from catalogs.
			51. Assemble bearings by fits, tolerances and alignments.
			52. Select the correct lubrication for bearings.
			53. Fit seals and shields when assembling bearings.
			54. Identify applications for radial and axial load on bearings.
			55. Maintain and troubleshoot bearings by identifying cause of failure.
			56. Service automatic lubrication.
			a. Check gauges.
			b. Check sight glasses.

Skills Required

A Prior to Emp.	B Upgrading	C Not Required	Technician will be able to:
			c. Check oil for contamination.
			d. Check automatic pumps, needle valves, cams.
			57. Select from service charts types of greases and oils for servicing a particular piece of equipment and cross reference for types of lubricants.
			58. Align couplings using indicators, straight edges, pieces of string.
			59. Assess foundations for suitability of installation considering vibrations, shimming and the correct use of rubber absorbers.
			60. Align pumps indicating the shafts and faces for squareness and co-axiallity of spindles or shafts.
			61. Read blueprints and sketch schematics.
			62. Perform basic shop mathematical functions such as speeds, eeds, tap drill sizes, areas, volumes, etc.

Skills Required

A Prior to Emp.	B Upgrading	C Not Required	Technician will be able to:
			PLUMBING
			63. Open clogged drains mechanically (using plunger and plumber tools), chemically, hydraulically and do preventative maintenance.
			64. Maintain pumps.
			a. Repack pumps, install couplings and align pumps.
			65. Overhaul pumps by disassemble, remove/install bearings, shafts impellers and packing and install mechanical seals.
			66. Repair pipes by excavation, shoring to OSHA standards, pipe coupling and clamp repair, roustabout and back-filling.
			67. Install sinks and lavatories.
			68. Change washers, fitters and screens on fixtures.
			69. Sweat a copper connection.
			70. Properly install PVC and ABS plastic pipe.
			71. Reset water closets, flush valve or flush box type.
			72. Read a plumbing diagram.

Skills Required

A Prior to Emp.	B Upgrading	C Not Required	Technician will be able to:
			CARPENTRY
			73. Make and repair formica counter tops.
			74. Make and repair work benches.
			75. Construct interior partitions and install manufactured portable partitions.
			76. Build and install shelves and small wall hung cabinets using machine wood working equipment.
			77. Install and maintain locks, hinges, and dead bolts.
			78. Rehang a door.
			79. Install acoustical tile.
			80. Install, tape, texture and paint drywall.
			81. Prepare and paint interior and exterior surfaces.
			82. Repair broken windows.
			83. Read blueprints, interpreting symbols and dimensions.

QUESTIONNAIRE

1. Total number of employees at your facility: _____

2. Total number of maintenance personnel. Name specific job titles and indicate how many for each.

3. Projected increase for 1 year _____, 3 years _____.

4. Expected replacements for 1 year _____, 3 years _____.

5. Are you providing in-house training for maintenance personnel? If so, explain:

6. Are your main personnel members of unions or labor organizations? If so, please list:

7. What technological advancements do you anticipate that may affect the:

   a) Requirements for employing maintenance personnel;

   b) Requirements for training;

   c) Job description.

   Please explain:

8. Would you be interested in providing further guidance in the development of this program?

Indicate with an X in one or more boxes if you feel the skill listed is of high frequency or importance for:

Column A - those skills necessary prior to employment
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Skills Required

A Prior to Emp.	B Upgrading	C Not Required	Technician will be able to:
			ELECTRICITY
			1. Relate wattage to HP.
			2. Relate mechanical energy to electrical energy.
			3. Understand concepts of Ohms law and be able to apply to series and parallel circuits.
			4. Convert mechanical energy from ft. lbs. into HP.
			5. Make safe and sound judgments in lifting and moving heavy equipment based on basic laws of physics.
			6. Understand potential energy of gears, shafts, motors, etc., in order to avoid safety hazards.
			7. Identify electrical malfunctions in electrical circuits with VOM or machine instrumentation such as troubleshooting to PCboard level.
			8. Identify and troubleshoot electrical components such as relays, fuses, circuit breakers, motor starters, switches, solenoics, coils and power supplies.
			9. Identify electrical malfunctions of transformers.
			10. Understand principles of AC and DC motors for preventative maintenance and to be able to work with electrician to identify electrical and mechanical failures.
			11. Field repair and install AC and DC motors.
			12. Install outlets for lighting, wall switches and receptables.
			13. Bend EMT (electrical metallic tubing) or thin wall conduit.
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			15. Utilize the current national electical code.

Skills Required

A Prior to Emp.	B Upgrading	C Not Required	Technician will be able to:
			16. Install romex cable types NM and NMC.
			17. Read electrical symbols from a blueprint and interpret electrical symbols as recognized by the American national standards.
			REFRIGERATION AND AIR CONDITIONING
			18. Silver braze and solder with oxygen-acetylene and air-acetylene torches.
			19. Identify by name and function the basic components of a refrigeration and air conditioning system.
			20. Leak check a refrigeration system with soap bubbles, Presto-lite leak detector and electronic leak detectors.
			21. Evacuate a system by using a two-stage vacuum pump with a micron vacuum gauge.
			22. Install a refrigeration manifold to a service valve system as well as a schrader valve system.
			23. Charge a refrigeration system by sight glass method, condenser temperature difference method, frost line method and amperage draw method.
			24. Diagnose mechanical refrigeration malfunctions and properly repair.
			25. Troubleshoot and repair single phase and three phase compressor electrical systems.
			26. Draw and interpret schematic and pictorial electrical diagrams.
			27. Determine heat loads on commercial refrigeration fixtures.

Skills Required

A Prior to Emp.	B Upgrading	C Not Required	Technician will be able to:
			28. Select necessary equipment, accessories and piping to install a refrigeration system.
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			31. Size and design hot and chilled water air conditioning systems as well as condenser water systems.
			32. Size and design air distribution systems.
			33. Do air analysis on a psychrometic chart.
			34. Read and interpret mechanical system blueprints.
			35. Identify and service pneumatic, electronic and electric controls.
			MECHANICAL MAINTENANCE
			36. Select and use correct hand tools such as hammers, chisels, files and other common tools.
			37. Use torque wrenches.

Skills Required

A Prior to Emp.	B Upgrading	C Not Required	Technician will be able to:
			38. Select and use special tools such as pin wrenches, impact wrenches, gear pullers, snap ring pliers, drifts, and make special tools for removing gears, bearings and seals.
			39. Do drilling and tapping (hand grinding of drills).
			40. Use all basic measuring tools such as micrometer scales, indicators, verniers.
			41. Use tachometers.
			42. Select the correct fasteners according to the tensile strength of the fastener.
			43. Insert heli-coils.
			44. Scrape bearings.
			45. Fit tapered pins of keys; i.e., cotter, straight, woodruff.
			46. Assemble gearing of shafts with correct clearance.
			47. Fit gibs to pulley shafts and check alignment of pulleys.
			48. Fit and adjust tension on vee belts and timing belts.
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			52. Select the correct lubrication for bearings.
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			54. Identify applications for radial and axial load on bearings.
			55. Maintain and troubleshoot bearings by identifying cause of failure.
			56. Service automatic lubrication.
			a. Check gauges.
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Skills Required

A Prior to Emp.	B Upgrading	C Not Required	Technician will be able to:
			c. Check oil for contamination.
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			57. Select from service charts types of greases and oils for servicing a particular piece of equipment and cross reference for types of lubricants.
			58. Align couplings using indicators, straight edges, pieces of string.
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			60. Align pumps indicating the shafts and faces for squareness and co-axiallity of spindles or shafts.
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			66. Repair pipes by excavation, shoring to OSHA standards, pipe coupling and clamp repair, roustabout and back-filling.
			67. Install sinks and lavatories.
			68. Change washers, fitters and screens on fixtures.
			69. Sweat a copper connection.
			70. Properly install PVC and ABS plastic pipe.
			71. Reset water closets, flush valve or flush box type.
			72. Read a plumbing diagram.

Skills Required

A Prior to Emp.	B Upgrading	C Not Required	Technician will be able to:
			CARPENTRY
			73. Make and repair formica counter tops.
			74. Make and repair work benches.
			75. Construct interior partitions and install manufactured portable partitions.
			76. Build and install shelves and small wall hung cabinets using machine wood working equipment.
			77. Install and maintain locks, hinges, and dead bolts.
			78. Rehang a door.
			79. Install acoustical tile.
			80. Install, tape, texture and paint drywall.
			81. Prepare and paint interior and exterior surfaces.
			82. Repair broken windows.
			83. Read blueprints, interpreting symbols and dimensions.

QUESTIONNAIRE

1. Total number of employees at your facility: _____.

2. Total number of maintenance personnel. Name specific job titles and indicate how many for each.

3. Projected increase for 1 year _____, 3 years _____.

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5. Are you providing in-house training for maintenance personnel? If so, explain:

6. Are your main personnel members of unions or labor organizations? If so, please list:

7. What technological advancements do you anticipate that may affect the:

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   Please explain:

8. Would you be interested in providing further guidance in the development of this program?

Indicate with an X in one or more boxes if you feel the skill listed is of high frequency or importance for:

Column A - those skills necessary prior to employment
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Skills Required

A Prior to Emp.	B Upgrading	C Not Required	Technician will be able to:
			ELECTRICITY
			1. Relate wattage to HP.
			2. Relate mechanical energy to electrical energy.
			3. Understand concepts of Ohms law and be able to apply to series and parallel circuits.
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			5. Make safe and sound judgments in lifting and moving heavy equipment based on basic laws of physics.
			6. Understand potential energy of gears, shafts, motors, etc., in order to avoid safety hazards.
			7. Identify electrical malfunctions in electrical circuits with VOM or machine instrumentation such as troubleshooting to PCboard level.
			8. Identify and troubleshoot electrical components such as relays, fuses, circuit breakers, motor starters, switches, solenoics, coils and power supplies.
			9. Identify electrical malfunctions of transformers.
			10. Understand principles of AC and DC motors for preventative maintenance and to be able to work with electrician to identify electrical and mechanical failures.
			11. Field repair and install AC and DC motors.
			12. Install outlets for lighting, wall switches and receptables.
			13. Bend EMT (electrical metallic tubing) or thin wall conduit.
			14. Work with rigid metal conduit.
			15. Utilize the current national electical code.

Skills Required

A Prior to Emp.	B Upgrading	C Not Required	Technician will be able to:
			16. Install romex cable types NM and NMC.
			17. Read electrical symbols from a blueprint and interpret electrical symbols as recognized by the American national standards.
			REFRIGERATION AND AIR CONDITIONING
			18. Silver braze and solder with oxygen-acetylene and air-acetylene torches.
			19. Identify by name and function the basic components of a refrigeration and air conditioning system.
			20. Leak check a refrigeration system with soap bubbles, Prestolite leak detector and electronic leak detectors.
			21. Evacuate a system by using a two-stage vacuum pump with a micron vacuum gauge.
			22. Install a refrigeration manifold to a service valve system as well as a schrader valve system.
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			24. Diagnose mechanical refrigeration malfunctions and properly repair.
			25. Troubleshoot and repair single phase and three phase compressor electrical systems.
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Skills Required

A Prior to Emp.	B Upgrading	C Not Required	Technician will be able to:
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			31. Size and design hot and chilled water air conditioning systems as well as condenser water systems.
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			33. Do air analysis on a psychrometic chart.
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			35. Identify and service pneumatic, electronic and electric controls.
			MECHANICAL MAINTENANCE
			36. Select and use correct hand tools such as hammers, chisels, files and other common tools.
			37. Use torque wrenches.

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			60. Align pumps indicating the shafts and faces for squareness and co-axiallity of spindles or shafts.
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			72. Read a plumbing diagram.

Skills Required

A Prior to Emp.	B Upgrading	C Not Required	Technician will be able to:
			CARPENTRY
			73. Make and repair formica counter tops.
			74. Make and repair work benches.
			75. Construct interior partitions and install manufactured portable partitions.
			76. Build and install shelves and small wall hung cabinets using machine wood working equipment.
			77. Install and maintain locks, hinges, and dead bolts.
			78. Rehang a door.
			79. Install acoustical tile.
			80. Install, tape, texture and paint drywall.
			81. Prepare and paint interior and exterior surfaces.
			82. Repair broken windows.
			83. Read blueprints, interpreting symbols and dimensions.

QUESTIONNAIRE

1. Total number of employees at your facility: _____

2. Total number of maintenance personnel. Name specific job titles and indicate how many for each.

3. Projected increase for 1 year _____, 3 years _____.

4. Expected replacements for 1 year _____, 3 years _____.

5. Are you providing in-house training for maintenance personnel? If so, explain:

6. Are your main personnel members of unions or labor organizations? If so, please list:

7. What technological advancements do you anticipate that may affect the:

   a) Requirements for employing maintenance personnel;

   b) Requirements for training;

   c) Job description.

   Please explain:

8. Would you be interested in providing further guidance in the development of this program?

Figure 1B

Indicate with an X in one or more boxes if you feel the skill listed is of high frequency or importance for:

Column A - those skills necessary prior to employment
Column B - those skills necessary for upgrading maintenance personnel
Column C - not required.

Skills Required

A Prior to Emp.	B Upgrading	C Not Required	Technician will be able to:
			ELECTRICITY
			1. Relate wattage to HP.
			2. Relate mechanical energy to electrical energy.
			3. Understand concepts of Ohms law and be able to apply to series and parallel circuits.
			4. Convert mechanical energy from ft. lbs. into HP.
			5. Make safe and sound judgments in lifting and moving heavy equipment based on basic laws of physics.
			6. Understand potential energy of gears, shafts, motors, etc., in order to avoid safety hazards.
			7. Identify electrical malfunctions in electrical circuits with VOM or machine instrumentation such as troubleshooting to PCboard level.
			8. Identify and troubleshoot electrical components such as relays, fuses, circuit breakers, motor starters, switches, solenoics, coils and power supplies.
			9. Identify electrical malfunctions of transformers.
			10. Understand principles of AC and DC motors for preventative maintenance and to be able to work with electrician to identify electrical and mechanical failures.
			11. Field repair and install AC and DC motors.
			12. Install outlets for lighting, wall switches and receptables.
			13. Bend EMT (electrical metallic tubing) or thin wall conduit.
			14. Work with rigid metal conduit.
			15. Utilize the current national electical code.

Skills Required

A Prior to Emp.	B Upgrading	C Not Required	Technician will be able to:
			16. Install romex cable types NM and NMC.
			17. Read electrical symbols from a blueprint and interpret electrical symbols as recognized by the American national standards.
			REFRIGERATION AND AIR CONDITIONING
			18. Silver braze and solder with oxygen-acetylene and air-acetylene torches.
			19. Identify by name and function the basic components of a refrigeration and air conditioning system.
			20. Leak check a refrigeration system with soap bubbles, Prestolite leak detector and electronic leak detectors.
			21. Evacuate a system by using a two-stage vacuum pump with a micron vacuum gauge.
			22. Install a refrigeration manifold to a service valve system as well as a schrader valve system.
			23. Charge a refrigeration system by sight glass method, condenser temperature difference method, frost line method and amperage draw method.
			24. Diagnose mechanical refrigeration malfunctions and properly repair.
			25. Troubleshoot and repair single phase and three phase compressor electrical systems.
			26. Draw and interpret schematic and pictorial electrical diagrams.
			27. Determine heat loads on commercial refrigeration fixtures.

Skills Required

A Prior to Emp.	B Upgrading	C Not Required	Technician will be able to:
			28. Select necessary equipment, accessories and piping to install a refrigeration system.
			29. Determine heat loads for air conditioning and heating on residential and commercial buildings.
			30. Diagnose and service ice machines, such as Scotsman, Cold-Draft, Whirlpool and Frigidaire.
			31. Size and design hot and chilled water air conditioning systems as well as condenser water systems.
			32. Size and design air distribution systems.
			33. Do air analysis on a psychrometic chart.
			34. Read and interpret mechanical system blueprints.
			35. Identify and service pneumatic, electronic and electric controls.
			MECHANICAL MAINTENANCE
			36. Select and use correct hand tools such as hammers, chisels, files and other common tools.
			37. Use torque wrenches.

Skills Required

A Prior to Emp.	B Upgrading	C Not Required	Technician will be able to:
			38. Select and use special tools such as pin wrenches, impact wrenches, gear pullers, snap ring pliers, drifts, and make special tools for removing gears, bearings and seals.
			39. Do drilling and tapping (hand grinding of drills).
			40. Use all basic measuring tools such as micrometer scales, indicators, verniers.
			41. Use tachometers.
			42. Select the correct fasteners according to the tensile strength of the fastener.
			43. Insert heli-coils.
			44. Scrape bearings.
			45. Fit tapered pins of keys; i.e., cotter, straight, woodruff.
			46. Assemble gearing of shafts with correct clearance.
			47. Fit gibs to pulley shafts and check alignment of pulleys.
			48. Fit and adjust tension on vee belts and timing belts.
			49. Balance (dynamic and static) shafts and pulleys.
			50. Select bearings from catalogs.
			51. Assemble bearings by fits, tolerances and alignments.
			52. Select the correct lubrication for bearings.
			53. Fit seals and shields when assembling bearings.
			54. Identify applications for radial and axial load on bearings.
			55. Maintain and troubleshoot bearings by identifying cause of failure.
			56. Service automatic lubrication.
			a. Check gauges.
			b. Check sight glasses.

Skills Required			
A Prior to Emp.	B Upgrading	C Not Required	Technician will be able to:
			c. Check oil for contamination.
			d. Check automatic pumps, needle valves, cams.
			57. Select from service charts types of greases and oils for servicing a particular piece of equipment and cross reference for types of lubricants.
			58. Align couplings using indicators, straight edges, pieces of string.
			59. Assess foundations for suitability of installation considering vibrations, shimming and the correct use of rubber absorbers.
			60. Align pumps indicating the shafts and faces for squareness and co-axiallity of spindles or shafts.
			61. Read blueprints and sketch schematics.
			62. Perform basic shop mathematical functions such as speeds, eeds, tap drill sizes, areas, volumes, etc.